Grade 11 Biology – Evolution (Day 8): Wet Lab on Natural Selection and Mutation

Curriculum Connections

Materials	Include in Appendix
❑ 1 Computer/student	❑ Chalkboard Plan (A)
❑ Internet	❑ Student Lab Handout (B)
❑ Media Cart/Projector	❑ Laboratory Checklist (B)
❑ Laboratory Handouts	❑ Laboratory Write-up Rubric (C)
❑ Laboratory Checklist	❑ Laboratory Write-up Checklist (D)
❑ Laboratory Rubric	❑ Sample Results for Teacher Resource (E)

Big Ideas

- Evolution is the process of biological change over time based on the relationships between species and their environments.
- The theory of evolution is a scientific explanation based on a large accumulation of evidence.
- Technology that enables humans to manipulate the development of species has economic and environmental implications.

Ministry Expectations - Overall Expectations

By the end of this course, students will:

C2. investigate evolutionary processes, and analyse scientific evidence that supports the theory of evolution

C3. demonstrate an understanding of the theory of evolution, the evidence that supports it, and some of the mechanisms by which it occurs.

Ministry Expectations - Specific Expectations

By the end of this course, students will:

C2.4 investigate, through a case study or computer simulation, the processes of natural selection and artificial selection and analyse the different mechanisms by which they occur [PR, AI, C]

C3.4 describe some evolutionary mechanisms (e.g., natural selection), and explain how they affect the evolutionary development and extinction of various species

Learning Goals

By the end of this lesson, students will:

- formulate hypothesis about the effect of natural selection on evolution, and genetic variation on evolution.
- perform and record a computer simulation to explore natural selection and evolution of a species
- analyse and interpret the data collected in the computer simulation on how a species evolves with natural selection factors and genetic variations, relating the data to the theory of evolution
- communicate using appropriate terminology their ideas about the lab, procedures, and results

Prior Knowledge

- Students will have a strong foundation in understanding that a theory is based on a large body of evidence, but is not necessarily perfectly accurate.
- Students will understand that the theory of evolution can be used to explain the history of life on earth.
- Students will have a basis of genetic variation, and that species evolve over time.
- Students will understand that the sources of genetic variation are mutations, which occur randomly and can be neutral, harmful or beneficial to the individual.
- Students will understand that Lamark's theory of evolution was flawed in some ways, in that evolution is not an individual passing on characteristics that they have acquired, but instead that they can pass on genetic mutations.

Time: 15 minutes **Before: Minds On**	**Activate Prior Knowledge** **Whole Class Discussion:** • Refresh student's memories about the theory of evolution, and key terms including: genetic variation, mutation, adaptation. • Discuss how mutations occur and how they affect genetic variation and evolution of a species. • Discuss the concept of natural selection, what 'natural factors' exist, and how it affects evolution of a species. • Introduce the online lab, using instructions on the student handout; show example of a first experiment they can do, and how they may fill in the chart; discuss the expectations for what they must hand in, and what you will look for and assess while you rotate throughout class (see attached rubric and checklist).	**Rationale for choice of T/L Strategy:** • Assesses prior knowledge and readiness • Allows gradual recall of information • Allows peers to share basic understanding • Make connections between the theory of evolution and natural selection, genetic variation, mutation, adaptation of species • Clarify the Lab Procedure	**Assessment Strategies:** Teacher will use questioning methods to gauge understanding of previous concepts (A as L). Students will also repeat lab instructions to confirm understanding (A as L).
Time: 45 minutes **During: New Concept**	**Small Group Discussion:** • As a class, students will repeat back what is expected of them, and will then perform the pre-lab questions and warm-up activity. • In small groups have students discuss what scenario they will start with and form a hypothesis; and then carry out the lab upon approval of the teacher.	**Rationale for choice of T/L Strategies:** • Allow students to communicate and discuss • Allows students to practice hypothesising • Allow students to support each other • Allows further concept refining of natural selection and how mutations occur • Allow students to construct new knowledge • Allow students to develop concepts using higher order thinking skills • Allow teacher time to interact with students, differentiate and assess for learning • Allow teacher to identify and challenge student misconceptions	**Assessment Strategies** Students will receive a checklist for what is required of them throughout the laboratory procedure (A for L), and a rubric for what is expected of them to hand in (A of L). **Differentiated Instruction:** Teacher will check in often with students who typically have trouble focusing.
Time: 10 minutes **After: Consolidation & Connection**	**Whole Class Discussion:** • Discuss as a class what some of the outcomes of the experiment were, and if any of them found a surprising result. • Discuss some of the discussion questions on the lab handout.	**Rationale for choice of T/L Strategy:** • To allow students to recall and review learning highlights to increase retention • To assess for learning for Next Steps • Assessment for learning to ensure Learning Goals are achieved	
Time: 5 minutes **Next Steps**	**Home-fun (and remainder of class)**: • Reiterate the expectations of what to hand-in with the students so that they know exactly what is required of them.	**Rationale for Choice of T/L Strategy:** • To assess for learning for Next Steps • Assessment of learning expectations • To allow students to practice summarizing expectations	

Appendix A - **Chalkboard Plan**

Definitions

Theory of Evolution: the scientific theory that describes changes in species over time and their shared ancestry.

Genetic Variation: the genetic variability among organisms, usually referring to individuals of the same species.

Mutation: a change in the genetic code of an allele; the change may have a positive effect, a negative effect, or no effect.

Adaptation: a characteristic or feature of a species that makes it well suited for survival or reproductive success in the environment.

Natural Selection: the way in which nature favours the reproductive success of some individuals within a population over others.

Lab-related Definitions

Variable: factor or condition that is subject to change, especially one that is allowed to change in a scientific experiment to test a hypothesis.

Controlled Variable: A standard of comparison for checking or verifying the results of an experiment.

What we will keep constant in the lab:

Environment

What we will change:

The mutations of the rabbits (long teeth, long tail, colour of fur)

The natural selection factor (wolves, plants)

How we will control variables:

We will do a reading with no mutation, using each one of our natural selection factors alone first so that we have something to compare what happens to the species when a mutation occurs introduced.

Appendix B – **Student Lab Handout** and **Student Checklist**

Name: _____

Lab: Natural Selection and Mutation

Purpose: To observe how genetic variance and natural selection affect the evolution of a rabbit species.

PART A/ Warm-up Questions:

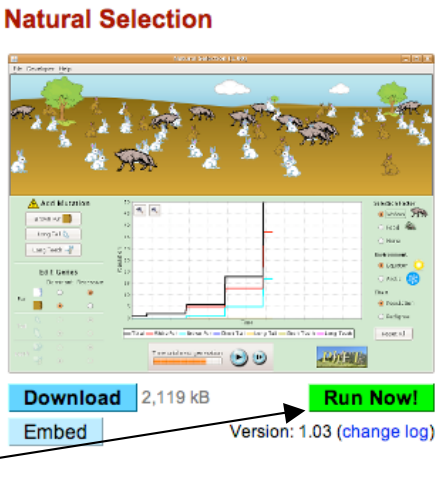
1. In an experiment, what is meant by 'a variable'?

2. What is a 'controlled variable'?

3. Why do we use controlled variables in experiments?

PART B/ Access the Lab:

Access the following simulation on your computer:
http://phet.colorado.edu/en/simulation/natural-selection



Select "Run Now!"

PART C/ Pre-Lab Questions:

1. What are the variables in this lab?

2. How will we 'control' the variables in this lab?

3. What will the graph show us?

4. Why do all of the rabbits die when we forget to 'add a friend'?

PART D/ Lab Introduction:

1. Get to know the controls

    a. To prepare for the experiment, first introduce a 'friend'.

    b. There is a bar at the bottom that displays when a new generation is introduced. Practice *pausing* the process (when you need to record something).

    c. Notice, as the experiment runs, there is a graph that tracks the population. Practice *zooming* out of the graph to view more of it.

    How many generations does it go through before the rabbits 'take over the world'? _____

    What is the number of rabbits at this point? _____

    d. Click 'Reset all'.

2. Ensure that your checklist below is complete and raise your hand and get permission from your teacher to begin the lab.

Student Checklist

- ❑ I have answered all of the Warm-up questions in Part A
- ❑ I have opened up the software program in Part B
- ❑ I have answered all of the Pre-lab questions in Part C
- ❑ I have done the Lab Introduction in Part D to get to know the tools and the program
- ❑ I have decided which natural selection factor and mutation I will test first.

PART E/ Lab Procedure:

In this lab we will use the computer simulation to help us collect data on the evolution of the rabbit species. We will introduce a mutation into the species (which is an anomaly in the genetic code of an individual), and then choose a natural selection factor (either a predator – wolves, or a limited food source), which will cause the population of your species to fluctuate. You will conduct the experiment for six different scenarios. Use chart on the following page to record your observations. At the end of the lab, you will be expected to submit a FORMAL lab report, as we have done in the past.

1. You will need to run the experiment with a 'control' group so that we will have something to compare the change in population to. You will record this in your observations chart.

    a. Introduce a 'friend' into the experiment.

    b. After 3 generations, pause the generations to record your population.

    c. Select 'wolves' as your (natural) selection factor. Restart the generations.

    d. Let the experiment run for a number of generations (between 3 and 4, as long as you are consistent for all of your experiments!).

    e. Record your observations of the population in the chart.

    f. Click 'Reset All'

2. Now you will test a mutation.

    a. Choose a mutation.

    b. Create a hypothesis of how you think the mutation will affect the evolution of the species. (Record in chart)

    c. Add a friend.

    d. After 3 generations, pause the generations to record your population.

    e. Select 'wolves' as your (natural) selection factor. Restart the generations.

    f. Let the experiment run for a number of generations (same as *Step 2*).

    g. Record your observations in the chart.

    h. Click 'Reset All'

3. Repeat step 2 for a different mutation

4. Repeat step 2 for the third mutation.

5. Repeat steps 1 to 4 for the limited food selection factor.

Observation Chart 1:

Experiment	Hypothesis (ie: (rabbit mutation) rabbits will be (more/less) likely to survive under (selective factor) because..... (explain how their trait will help them or not))	Phenotype (mutation)	Selective Factor	Initial Population at Generation 3	Final Population	Conclusion/ Observation
Control group		None	Wolves	No mutation:	No mutation:	
				Mutation: 0	Mutation: 0	
				Total:	Total:	
Experiment 1			Wolves	No mutation:	No mutation:	
				Mutation:	Mutation:	
				Total:	Total:	
Experiment 2			Wolves	No mutation:	No mutation:	
				Mutation:	Mutation:	
				Total:	Total:	
Experiment 3			Wolves	No mutation:	No mutation:	
				Mutation:	Mutation:	
				Total:	Total:	

Observation Chart 2:

Experiment	Hypothesis	Phenotype (mutation)	Selective Factor (wolves or food)	Initial Population at Generation 3	Final Population	Conclusion/ Observation
Control group		None	Limited Food	No mutation:	No mutation:	
				Mutation: 0	Mutation: 0	
				Total:	Total:	
Experiment 1			Limited Food	No mutation:	No mutation:	
				Mutation:	Mutation:	
				Total:	Total:	
Experiment 2			Limited Food	No mutation:	No mutation:	
				Mutation:	Mutation:	
				Total:	Total:	
Experiment 3			Limited Food	No mutation:	No mutation:	
				Mutation:	Mutation:	
				Total:	Total:	

PART F/ Discussion Questions:

1. Why does the rabbit population depend on the availability of food?

2. Were there any instances where you noticed that the rabbits with a mutation increased in population and surpassed the population of the rabbits without a mutation? Which combinations of mutation and natural selection factor did this happen?

3. Use Darwin's theory of evolution and natural selection to explain **why** you observed what you did in Question 1.

4. What are 2 other natural section factors that affect animal populations in the real world?

5. What is another mutation that we might see in a rabbit?

6. How might the rabbit species evolve as climate change begins to affect their environment?

Appendix C – **Rubric for Laboratory Write-up**

Category	Component	Level 4	Level 3	Level 2	Level 1
Knowledge and Understanding	**Introduction**	Demonstrates thorough background knowledge of the theory of evolution.	Demonstrates considerable background knowledge of the theory of evolution.	Demonstrates some background knowledge of the theory of evolution.	Demonstrates limited background knowledge of the theory of evolution.
	Purpose	Demonstrates thorough understanding of reason for lab.	Demonstrates considerable understanding of reason for lab.	Demonstrates some understanding of reason for lab.	Demonstrates limited understanding of reason for lab.
Thinking and Investigation	**Hypothesis**	Develops appropriate hypotheses with a high degree of effectiveness.	Develops appropriate hypothesis with considerable effectiveness.	Develops appropriate hypothesis with some effectiveness.	Develops appropriate hypothesis with limited effectiveness.
	Methodology	Uses planning skills to create a methodology for the lab with a high degree of effectiveness.	Uses planning skills to create a methodology for the lab with considerable effectiveness.	Uses planning skills to create a methodology for the lab with some effectiveness.	Uses planning skills to create a methodology for the lab with limited effectiveness.
	Results	Records and gathers data with a high degree of effectiveness.	Records and gathers data with a considerable effectiveness.	Records and gathers data with some effectiveness.	Records and gathers data with limited effectiveness.
	Analysis	Demonstrates critical thinking strategies to interpret the data with a high degree of effectiveness. Responds to and supports discussion question answers with a high degree of effectiveness.	Demonstrates critical thinking strategies to interpret the data with considerable effectiveness. Responds to and supports discussion question answers with considerable effectiveness.	Demonstrates critical thinking strategies to interpret the data with some effectiveness. Responds to and supports discussion question answers with some effectiveness.	Demonstrates critical thinking strategies to interpret the data with limited effectiveness. Responds to and supports discussion question answers with limited effectiveness.
	Conclusion	Forms and justifies conclusions on the basis of evidence to a high degree of effectiveness.	Forms and justifies conclusions on the basis of evidence with considerable effectiveness.	Forms and justifies conclusions on the basis of evidence with some effectiveness.	Forms and justifies conclusions on the basis of evidence with limited effectiveness.
Communication	**Organization**	Expresses and organizes ideas and information with a high degree of effectiveness.	Expresses and organizes ideas and information with considerable effectiveness.	Expresses and organizes ideas and information with some effectiveness.	Expresses and organizes ideas and information with limited effectiveness.
	Vocabulary and terminology	Uses vocabulary and terminology of the topic with a high degree of effectiveness.	Uses vocabulary and terminology of the topic with considerable effectiveness.	Uses vocabulary and terminology of the topic with some effectiveness.	Uses vocabulary and terminology of the topic with limited effectiveness.
Application	**Scientific Process**	Applies scientific investigation skills with a high degree of effectiveness.	Applies scientific investigation skills with considerable effectiveness.	Applies scientific investigation skills with some effectiveness.	Applies scientific investigation skills with limited effectiveness.
	Transfer of Knowledge	Applies theory of evolution to the scientific analysis with a high degree of effectiveness.	Applies theory of evolution to the scientific analysis with considerable effectiveness.	Applies theory of evolution to the scientific analysis with some effectiveness.	Applies theory of evolution to the scientific analysis with limited effectiveness.
	Connections to society and the environment	Makes connections between evolutionary processes, society and the environment with a high degree of effectiveness.	Makes connections between evolutionary processes, society and the environment with considerable effectiveness.	Makes connections between evolutionary processes, society and the environment with some effectiveness.	Makes connections between evolutionary processes, society and the environment with limited effectiveness.

Appendix D –**Laboratory Write-up Checklist and Expectations**

Name: _____

- ❑ I have completed Part A to Part E of the lab and answered all of the questions.
- ❑ I have typed up my laboratory report on a computer.
- ❑ I have included an **introduction**.
- ❑ I have included a **purpose.**
- ❑ I have included a **hypothesis.**
- ❑ I have included a **list of materials.**
- ❑ I have included a **method.**
- ❑ I have included my **results and observations.**
- ❑ I have included a **discussion** of why I think the results happened**.**
- ❑ I have included an **analysis,** which includes my answered questions from Part E.
- ❑ I have attached all of my rough written work from the in-class laboratory.
- ❑ I have written my name on my laboratory write-up.
- ❑ I have handed my write-up in to my teacher.

Appendix E – **Sample Results for Teacher**

Experiment	Hypothesis	Phenotype (mutation)	Selective Factor (wolves or food)	Initial Population at Generation 3	Final Population	Conclusion/ Observation
Control group		None	Limited Food	No mutation: Mutation: 0 Total:	No mutation: Mutation: 0 Total:	
Experiment 1: Long teeth versus food	Long teeth rabbits will be likely to survive against a limited food source natural selection because they will help them chew through tough branches.	Long teeth	Limited Food	No mutation: 38 Mutation: 15 Total: 53	No mutation: 18 Mutation: 36 Total: 54	At first there were more non-mutated rabbits than rabbits with long teeth. After the food was introduced, the long teeth rabbits' population overtook the population of the non-mutated rabbits.

Experiment	Hypothesis	Phenotype (mutation)	Selective Factor (wolves or food)	Initial Population at Generation 3	Final Population	Conclusion/ Observation
Control group		None	Wolves	No mutation: Mutation: 0 Total:	No mutation: Mutation: 0 Total:	
Experiment 1: Long tails versus wolves	Long tail rabbits will be likely to survive under wolves natural selection because it will help them jump higher.	Long tails	Wolves	No mutation: 38 Mutation: 15 Total: 53	No mutation: 0 Mutation: 0 Total: 0	At first there were more non-mutated rabbits than rabbits with long tails because it took some time for the mutation to come into the population. The population began to fluctuate when the wolves were introduced. The long tails died off, maybe because it was easier for the wolves to catch them. All of the rabbits died in the end.